Acta Orthop Scand 55, 146–151, 1984

Total hip replacement with a straight stem prosthesis

A 2-year follow-up of 126 CAD operations

The clinical and radiographic results in 126 primary CAD total hip replacements were assessed after 2 years in a prospective study. The clinical overall results were satisfactory, with 89 per cent of the hips being free from significant pain. Femoral component loosening was radiographically evident in 6 per cent. The walking speed was increased by 83 per cent in patients with unilateral hip disease. This increase was partly achieved during the second postoperative year.

Key words: hip arthroplasty; hip joint, surgery; joint motion; joint prosthesis; locomotion.

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The geometry of the femoral stem may influence the risk of aseptic loosening (McBeath & Foltz 1979, Pellicci et al. 1979, Sutherland et al. 1982). As a consequence of a relatively high frequency of stem loosening found in Charnley-Müller arthroplasties (Olsson et al. 1979), we abandoned this device in favour of the straight-stem CAD prosthesis. A prospective clinical and radiological study was undertaken to evaluate the results.

Patients and methods

From September 1978 through March 1980, the CAD prosthesis was used in 126 consecutive primary hip arthroplasties in 123 patients (65 women and 58 men). The mean age at the time of operation was 68 (30–85) years. One hip had been reoperated on with exchange of the femoral component because of instability, and 14 patients with 15 operated hips had died before the 2-year follow-up, which thus included 110 arthroplasties in 108 patients (59 women and 49 men). The preoperative diagnoses were primary osteoarthritis in 74 hips, hip fracture complications in 20, rheumatoid arthritis, ankylosing spondylitis and SLE in 12, primary femoral head osteonecrosis in two and CDH in two hips. Twenty hips had previously been operated on: 14 with osteosynthesis of fractures, three with intertrochanteric osteotomy and three with femoral head replacement.

The patients' average weight was 72 kg. One third of the patients weighed 80 kg or more.

The approach to the hip was anterolateral in 109 operations and posterolateral in one. Osteotomy of the greater trochanter was done in 33 hips. In the majority of operations, a bone plug was used to close the femoral canal distally and the cement was introduced retrogradely. No special instruments were used for cleaning the bone surfaces or pressurization of the cement. The cement was radiopaque, with high or intermediate viscocity. The femoral components were of the CAD, straight-stem type, with 32 mm head diameter. The postoperative regime, antibiotic prophylaxis and methods of assessment were the same as previously described (Olsson et al. 1979, 1981).

A follow-up examination 1 year postoperatively included walking speed measurement, Trendelenburg's test and recording of the use of walking aids. At 2 years postoperatively, we also recorded pain, range of motion and walking capacity, using the numerical rating system advocated by Charnley (1972).

Radiographs were taken of all hips preoperatively, about 2 weeks after the operation, and 2 years postoperatively. All measurements on the films were corrected for magnification. On the primary radiogram we registered the position of the prosthesis and the distribution of the cement. The follow-up radiograms were analyzed with regard to signs of loosening of the prosthesis components, healing of transplants and osteotomies and femoral neck resorption.

Results

Complications

In the total of 126 arthroplasties, peroperative fracture of the greater trochanter occurred in

11 hips. Seven patients had clinically diagnosed deep vein thrombosis or pulmonary embolism, and they were all successfully treated with anticoagulants. One patient had postoperative bronchopneumonia. In one hip the osteotomized greater trochanter had to be reattached after 16 days. Six patients had transitory secretion from the skin wounds with positive cultures but without early or late signs of deep infection. Three hips dislocated early, but after closed reduction none of them has redislocated. One hip with recurrent dislocations as a result of prosthesis malposition was reoperated on with exchange of the femoral component after 6 months and is not included in the follow-up. There were no deaths during the first 6 months after the operations.

FOLLOW-UP

	Grade	1	2	3	4	5	6	
	1			2	6	1		9
PREOP.	2			1	8	9	2	20
	3				14	14	7	35
	4				5	16	16	37
	5						7	7
	6						2	2
		–	–	3	33	40	34	Sum

Figure 2. Numerical grading (Charnley 1972) for pre- and postoperative range of motion in 110 total hip replacements.

Clinical results

Before the operation, 86 per cent of the hips were in the worst three grades for pain. At the follow-up, 89 per cent were free from significant pain (Figure 1). Five patients were rated in grade 3 both pre- and postoperatively. One of these patients had a loose femoral component and was later reoperated. In the remaining four hips there were no signs of loosening. The range of motion (Figure 2) had improved in 103 hips with two-thirds in the top grades. The preoperative ratings for walking capacity (Figure 3) were in the upper three grades in only 11 hips as compared to 67 at the follow-up.

It should be noted that only 25 hips were classified into category A (Charnley 1972), which implies unilateral hip involvement and absence of other factors impairing walking. Maximum walking speed had been examined preoperatively in 22 of the 25 category A pa-

FOLLOW-UP

	Grade	1	2	3	4	5	6	
	1					4		4
PREOP.	2				2	3	10	15
	3			5	5	23	43	76
	4					6	8	14
	5							–
	6						1	1
		–	–	5	7	36	62	Sum

Figure 1. Numerical grading (Charnley 1972) for pre- and postoperative pain in 110 total hip replacements.

FOLLOW-UP

	Grade	1	2	3	4	5	6	
	1	1	3	2			1	7
PREOP.	2	1	10	14	21	2		48
	3		3	8	17	7	9	44
	4			1	4		3	8
	5				1	2		3
	6							–
		2	16	25	43	11	13	Sum

Figure 3. Numerical grading (Charnley 1972) for pre- and postoperative walking capacity in 110 total hip replacements.

Table 1. Use of walking aids before total hip replacement and at follow-up examinations 1 and 2 years postoperatively in 25 subjects with unilateral hip involvement

	One or two supports		No support
	Always	Outdoors only	
Preoperatively	22	2	1
1 year after THR	–	21	4
2 years after THR	–	11	14

tients (average age 68 years). The average maximum speed was 39 ± 19 m/min before the operation, 66 ± 16 m/min at the 1-year follow-up, and 72 ± 19 m/min at the 2-year follow-up. Eighteen of the 22 patients could walk faster at the 2-year as compared to the 1-year follow-up; in one, maximum walking speed was unchanged and in three it had decreased by 3 m/min or less. During the second postoperative year, 10 patients abandoned the stick which they had used for outdoor walking (Table 1).

In 96 hips, Trendelenburg's test was carried out both 1 and 2 years postoperatively. Eleven of these changed from positive to negative during this interval, whereas three changed from negative to positive.

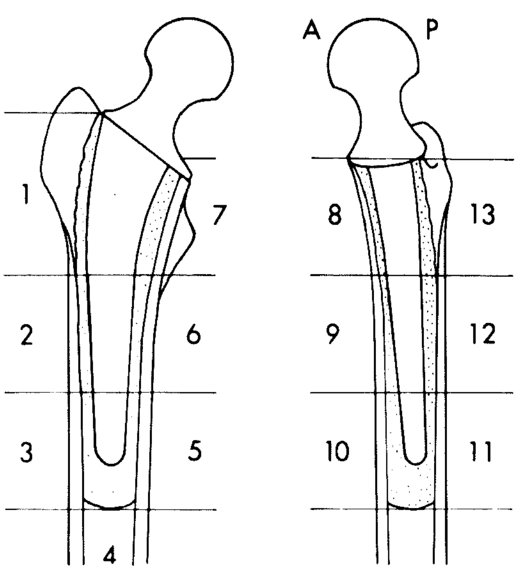

Figure 4. The frontal and lateral projections of the proximal femur were divided into zones for evaluation of cement filling and changes related to prosthesis loosening.

Radiographic findings

In the review of the anteroposterior films, the proximal femur was divided into seven zones (Gruen et al. 1979), and the lateral projection was correspondingly divided into six zones, marked 8 to 13 (Figure 4). The cementing was considered defective if the cement layer at any point within a zone was less than 1 mm thick. Cement defects in one or more zones were noted in the frontal projection in 44 hips and in the lateral projection in 61 hips (Table 2). In only 31 hips was a continuous cement layer of at least 1 mm thickness noted in both the frontal and the lateral projection. The cement layer in zone 7 was separately measured at the thinnest point. It was absent in four hips and measured 1–2 mm in 38, 3–4 mm in 40, and 5 mm or more in only 32 hips.

The angle between the longitudinal axis of the femur and the midline of the straight part of the prosthesis stem varied from 5 degrees of valgus to 13 degrees of varus (the latter occurring in the only hip in which a short stem was used). The mean angle was 1.6 degrees of varus (Table 3). Osseous healing was noted in 28 out of the 33 trochanteric osteotomies. In five of the osteotomies and two of the 11 trochanteric fractures, the fragments were displaced. The

Table 2. Location of cement defects around the femoral component in 79 CAD total hip replacements. Zone numbering: see Figure 4

Frontal projection		Lateral projection	
Zone	No. of defects	Zone	No. of defects
1	10	8	13
2	17	9	13
3	23	10	1
4	2	11	48
5	10	12	1
6	5	13	9
7	4		

Table 3. Prosthesis stem-femoral shaft angle in 110 CAD total arthroplasties

	Varus				Valgus		
Angle (degrees)	≥5	3–4	1–2	0	1–2	3–4	≥5
Number	15	25	30	22	8	9	1

bone transplants used for acetabular reconstruction in the four hips with protrusio acetabuli and the two CDH hips were all intact.

Loosening of the acetabular component was suspected in one hip with protrusio acetabuli, where a radiolucent line measuring 1.5–2 mm encircled half the periphery of the socket. Loosening of the femoral component was evident in seven hips, and in five additional hips we noted signs of suspected loosening subsidence.

We based the diagnoses of prosthesis loosening on the following observations: one of the seven loose femoral components was later exchanged in a reoperation, which confirmed the loosening; in the remaining six, metal-cement separation of 1–2 mm was present in zone 1, combined in four hips with a varus shift of 2–3 degrees and in two hips with dorsolateral cortical erosion at the prosthesis tip through ⅓ of the thickness of the cortex. Subsidence, measuring 4–6 mm, was found in three hips, and cortical erosions around the cement in three. These erosions were confined to three zones in two hips and extended over six zones in one hip. None of the patients with cortical erosions had pain or an elevated sedimentation rate.

In the five hips with suspected femoral stem loosening, three components had subsided together with the cement into the femur by 4, 6 and 11 mm, respectively. In the remaining two hips, a metal-cement separation of 0.5 mm in zone 1 was noted, in one of them combined with a subsidence of 2 mm. Radiolucent zones at the cement-bone interface limited to one or two zones, maximum 1 mm wide and distinctly outlined by a thin sclerotic zone, were not regarded as a sign of loosening; they were interpreted as a reaction to the operative trauma and the foreign material in the cancellous bone (Charnley et al. 1968, Reckling et al. 1977).

Femoral neck resorption

Femoral neck resorption was observed in 68 of the 98 hips without signs of loosening. The resorption was on average 3 (1–9) mm. It appeared as smooth cortical atrophy in 62 hips, and in five there was also new bone formation. In one, it was irregular with small cystic erosions and 6 mm of shortening. Eleven of the 12 hips with evident or suspected femoral stem loosening had femoral neck resorption averaging 5 (1–11) mm.

Discussion

The relatively high incidence of loosening which we found with the curved Müller stem was our reason for abandoning it in favour of the straight CAD stem. The main purpose of this study was to establish whether a stem with a different geometry would reduce the incidence of loosening to an acceptable level or if further improvements were required. The rate of loosening is related to time (Carlsson & Gentz 1980, Stauffer 1982, Sutherland et al. 1982) and the short observation time in our series does not allow any conclusions about the long-term results. Our 2-year follow-up time was chosen in order to get a preliminary conception of the results and the need for further improvements.

Femoral component loosening, defined as a change in position which is not purely axial, was found in 6 per cent. In the additional five hips with suspected loosening, mainly in the form of an axial migration, further progress with clinical significance is not necessary, as shown by Griffith et al. (1978), who found progress of femoral stem subsidence in only 10 out of 47 hips during the interval between 2 and 8 years postoperatively. The incidence of loosening was high compared to that reported by Harris et al. (1982), who found only two definitely loose stems in 171 arthroplasties with CAD and HD-2 components, followed for 2–5 years. The difference can hardly be explained by demographic factors. Sex distribution and average weight of the patients were not significantly different, and the patients in Harris' series were on average 8 years younger; this would rather involve a greater risk of prosthesis loosening (Carlsson & Gentz 1980, Olsson et al. 1981, Sutherland et al. 1982).

In our earlier series of Müller arthroplasties with 6 years' observation time on average (Olsson et al. 1981), femoral stem loosening was proven or suspected in 46 per cent. Gruen et al. (1979) found a loosening rate of 20 per cent with

3 years' average follow-up. The corresponding rate in the present series was 11 per cent.

Five of our seven patients with loose femoral stems were men. Age and body weight did not differ from the material as a whole. The preoperative diagnosis was primary osteoarthritis in only three hips, fracture complications in two, osteonecrosis in one and rheumatoid arthritis in one.

Inadequate cementing technique and improper positioning of the implant may be responsible for the high incidence of loosening in our series. When the femoral canal was plugged with cancellous bone and the cement was injected with a gun, the closure was not always complete. No special instruments for preparing the bone surface were used. Six of the seven loose femoral implants were placed in varus, ranging from 3 to 6 degrees. The seventh was neutrally placed in a patient with rheumatoid arthritis and severe osteoporosis. Only one of the loose stems had a continuous cement layer covering it completely in both projections and a minimum of 5 mm of cement thickness in zone 7. Four had incomplete cement coverage in zone 11, with the distal end of the stem in contact with the cortex.

The clinical results were satisfactory, with 89 per cent of the hips free from significant pain. The average increase of maximum walking speed was 83 per cent in those patients who had unilateral hip involvement and no other disability impairing walking, which is in agreement with earlier observations (Arborelius et al. 1976).

We have found indications that the functional rehabilitation period after hip arthroplasty may extend beyond the first postoperative year, as demonstrated by increased walking speed, reduced dependence on walking aids and a decreased number of Trendelenburg positive hips at 2 years as compared to 1 year postoperatively.

Femoral neck resorption was found in 69 per cent of the hips without any signs of stem loosening. In our 5–10-year follow-up of Charnley-Müller arthroplasties (Olsson et al. 1981), the corresponding figure was 35 per cent. This is in accordance with the report by Hierton et al. (1983), who found neck resorption to be more common in CAD than in Charnley-Müller arthroplasties 3 years after surgery. A possible explanation of this difference is the greater stress protection of the medial neck provided by the heavier CAD implant. Both types of implant are provided with a collar, the biomechanical effect of which is, however, not altogether clear. The high incidence of neck resorption means that in a majority of arthroplasties, after a relatively short time, direct metal-to-bone transfer of load to the cut end of the medial neck no longer takes place. The possible advantage of such "collar-calcar contact", claimed on the basis of theoretical and experimental work (Hinterberger & Ungethüm 1977, Oh & Harris 1978), is obviously of limited clinical value. On the other hand, the adverse biomechanical effects of a small amount of neck resorption on stress distribution and fixation of the femoral implant have been shown to be minimal (Brockhurst & Svensson 1977, Huggler et al. 1978).

Acknowledgements

Financial support was obtained from Östergötlands Läns Landstings Medicinska Forskningsnämnd (project no. 43/81) and from the Fredga Foundation.

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